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Journal of Magnetism and Magnetic Materials 215–216 (2000) 210–212

Journal of magnetism and magnetic materials

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Mössbauer studies of superexchange interactions and atomic migration in $CoFe_2O_4$

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Abstract

The Co ferrite, $CoFe_2O_4$, has been investigated by X-ray diffraction and Mössbauer spectroscopy. The crystal structure is found to be an inverse cubic spinel with the lattice constants $a_0 = 8.381 \pm 0.005$ Å and 8.391 ± 0.005 Å for slowly cooled and quenched $CoFe_2O_4$, respectively. The iron ions are in ferric Fe^{3+} states. The temperature dependence of the magnetic hyperfine fields of ^{57}Fe at the tetrahedral (A) and octahedral (B) sites is analyzed by the Néel theory of ferrimagnetism. For the slowly cooled sample, the A–B intersublattice superexchange interaction is found to be antiferromagnetic with a strength of $J_{A\text{–}B} = -24.4k_B$, while A–A and B–B intrasublattice superexchange interactions are antiferromagnetic and ferromagnetic with $J_{A\text{–}A} = -18.2k_B$ and $J_{B\text{–}B} = 3.9k_B$, respectively. For the quenched sample $J_{A\text{–}B} = -23.6k_B$, $J_{A\text{–}A} = -17.8k_B$, and $J_{B\text{–}B} = 3.9k_B$ are found. The decrease of the Mössbauer absorption area ratio of A to B patterns above 400 K is explained in terms of migrating iron ions from A to B sites.

Keywords: Co ferrite; Mössbauer spectroscopy; Superexchange interaction; Atomic migration; Debye temperature